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AGRICULTURAL MEMORANDUM NO 807

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THE ESTIMATION OF ACCUMULATED VAPOUR PRESSURE DEFICIT FROM OTHER METEOROLOGICAL DATA AND ITS APPLICATION TO GRASS CONSERVATION.

INTRODUCTION

In most previous Agricultural Memoranda dealing with weather suitable for grass conservation the criterian used has been the lack of significant rain over a 24 hour period from 0900 each day. Agricultural Memorandum No 628 (FPS) represented an important advance by incorporating a measure of humidity - the daily accumulated vapour pressure deficit - into a wilting model. This was done by using computer printouts of 3 hourly vapour pressure deficits for Shawbury and, after making an allowance for the 24 hour rainfall total, finding the number of days required to reach the total accumulated vapour pressure deficit necessary to wilt the grass crop to 25% moisture content. The usefulness of this direct approach is severely limited because of the small number of stations for which vapour pressure deficit data is accessible by computer and also the unsatisfactory geographical distribution of such stations. Here an attempt has been made to estimate the daily accumulated vapour pressure deficit from meteorological data measured at 0900 GMT each day. The results of these estimates were then used in a wilting model similar to that of FPS to obtain a frequency distribution of the number of days to make hay.

CHOICE OF PARAMETERS

Using the previously extracted vapour pressure deficit data for Shawbury for 1962 multiple regressions were done with various parameters measured at 0900 GMT at the same station. After considerable trial and error the most satisfactory correlation obtained was:-

$$ZVPD = 156 + .242\ T_x^2 - 1.89\ RH - rr$$

where ZVPD is the daily accumulated vapour pressure deficit ignoring nocturnal values of less than 1 mb.

T_x the maximum temperature ^{o}C

RH the 0900 relative humidity %

rr the rainfall measured at 0900 GMT the FOLLOWING day mm

The multiple regression co-efficient obtained was 0.88 for the 80 day period starting on 15 May 1962.

The results were sufficiently encouraging to attempt to use the 0900 GMT data to directly derive the distribution of days to wilt to 25% moisture content.

MODEL USED

FPS had found it very tedious to derive the distribution manually and so his model was modified slightly and a programme written for the Wang computer to obtain the number of days to wilt using 0900 GMT data as the input. The regression co-efficients given above were used and it was assumed that a total of 450 mb hrs would be required for grass cut on 15 May decreasing by 2 mb hr per day thereafter. The reduction of the daily total by 4 mb hr per mm of rain was retained and as before negative values allowed to stand. Figure 1 compares the distributions of days to wilt from

FH23

the estimated and actual data for Shawbury for 10 years, 1961-70, taking a 70 day period starting on 15 May each year. The agreement is surprisingly good but as figure 2 shows can be improved markedly. This improvement was obtained by trial and error and was achieved by altering the regression constant from 156 to 146. To test if the agreement was accidental figure 3 shows a comparison of the distribution for the 5 year period 1961-1965 agreement is still good apart from some irrelevant discrepancies towards the tail of the distributions.

As a more severe test the distribution was estimated for a 5 year period 1964-68 at Aberporth using the unmodified multiple regression equation Figure 4. Here for a very different climate the fit is not so good as the peak of the distribution is shifted to a lower value. However even using a regression equation derived from one year's Aberporth data the fit is still poor as shown in figure 5. This poorer fit at Aberporth is probably due to the arbitary time of onset of the sea breeze and consequent change of air mass. However as figures 6 and 7 show the method does substantially account for the difference in distributions of the 2 climatically very different sites.

Finally to see if the method could cope with variations in time to wilt in a particular season the estimated and 'actual' number of days to wilt are shown for Shawbury 1964 in figure 8. Considering the crudeness of the assumptions the agreement is very gratifying.

CONCLUSIONS

This memorandum illustrates that it appears to be possible to incorporate both rainfall and humidity in a grass wilting model using meteorological variables measured once a day. Such data are more widely available than hourly on 3 hourly data and have a reasonable geographical distribution. The model here has been used to ascertain the time taken to make hay but by suitable adjustment to the accumulated vapour pressure deficit for the degree of wilting required it could equally well be used for other methods of conservation. It is also possible that accumulated vapour pressure deficits estimated in this way could be used in other agrometeorological investigations where humidity is one of the important factors. Although the use of the Wang computer considerably reduced the labour involved compared to the first manual calculations the data entry is still tedious. The results seem sufficiently encouraging to make it worth writing a programme for COSMOS to operate directly on the main computer data bank to produce frequency distributions for a large selection of stations.

REFERENCES

F P Sims 1974. Agricultural Memorandum No 628 - A method for estimating work days for grass conservation using accumulated vapour pressure deficit.

Any comments or suggestions on this paper should be sent to the author.

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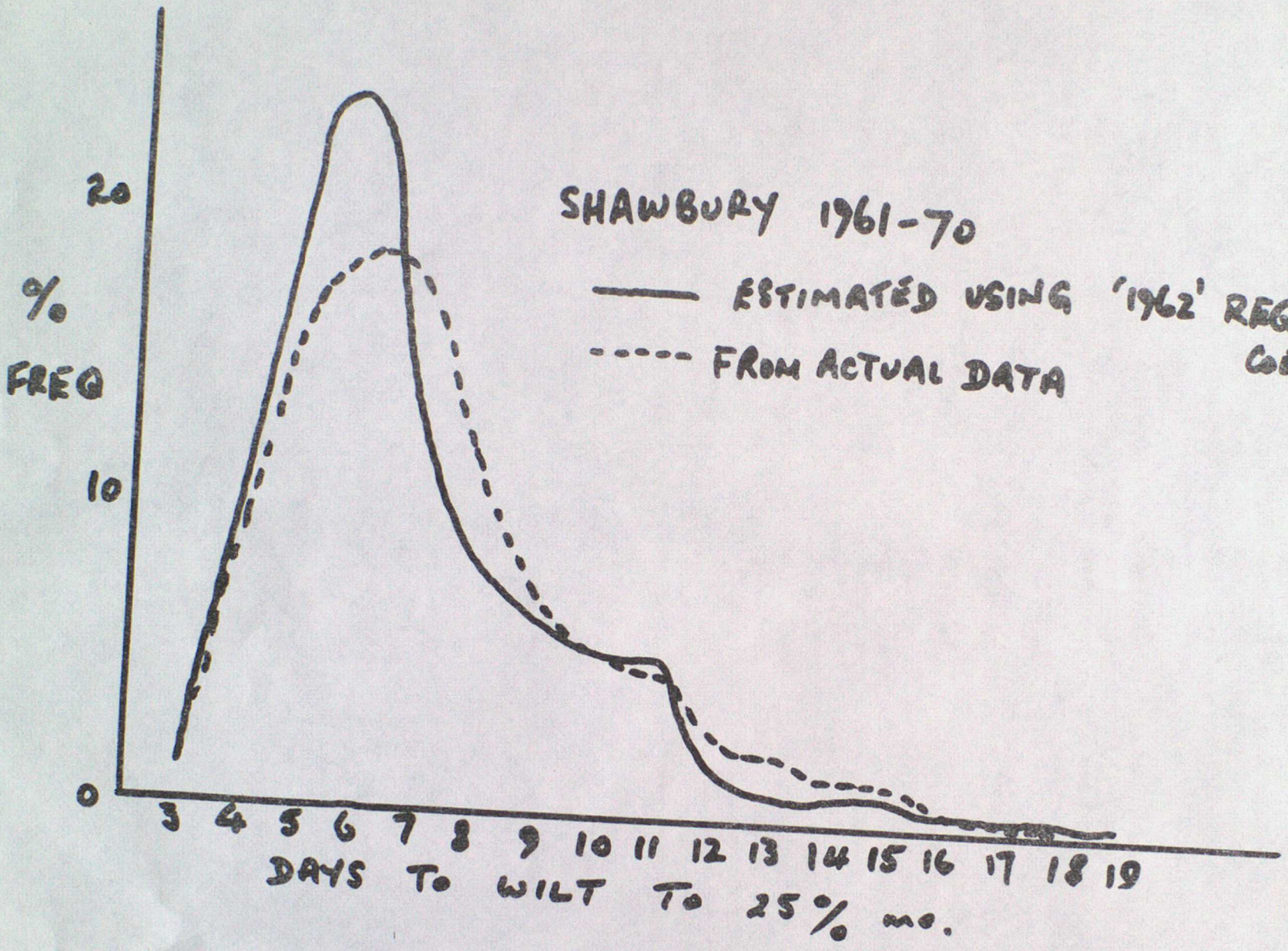

SHAWBURY 1961-70
—— ESTIMATED USING '1962' REGRESSION COEFFICIENTS
----- FROM ACTUAL DATA
% FREQ
20
10
0
3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
DAYS TO WILT TO 25% mc.

FIGURE 1.

FIGURE 3

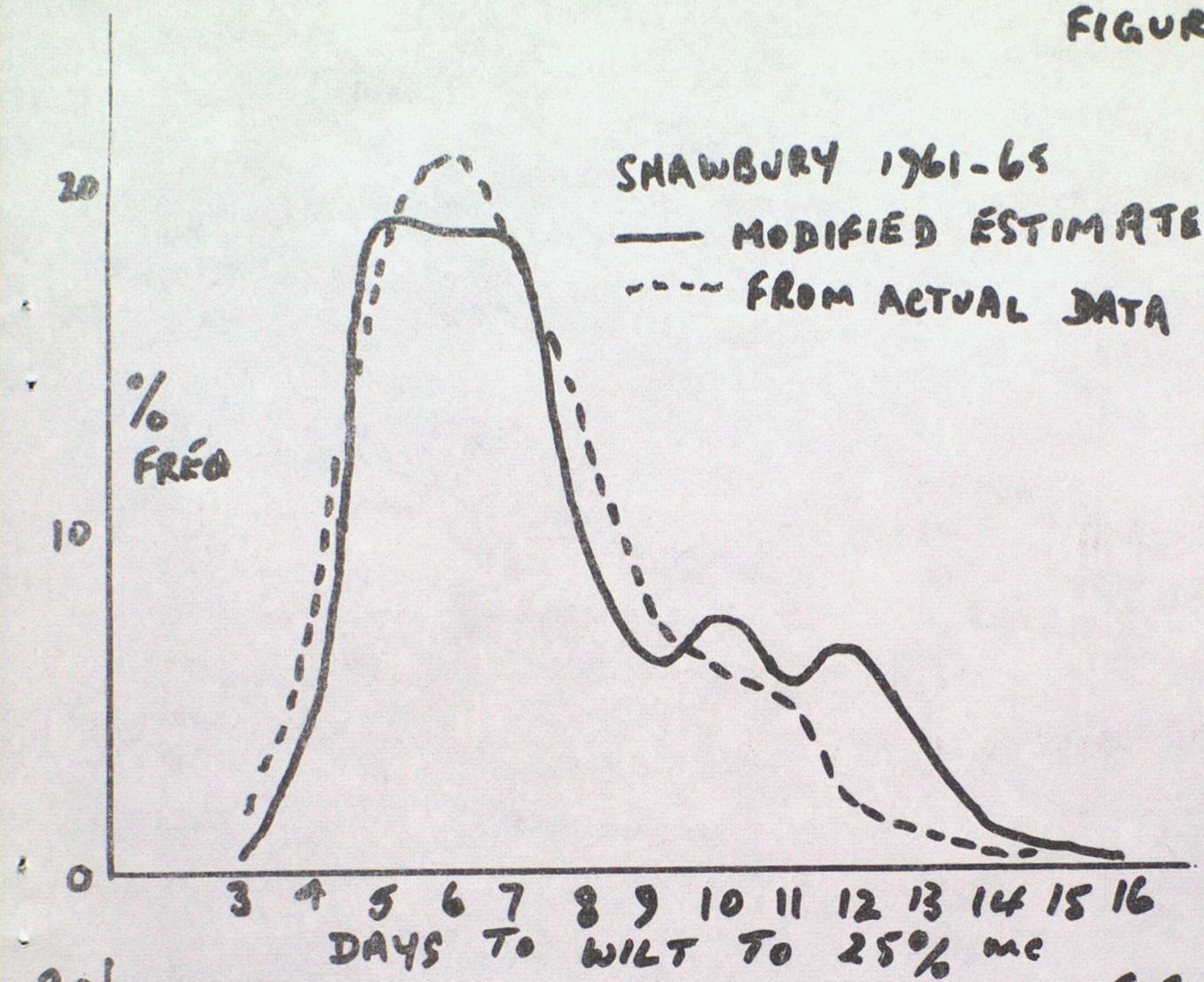
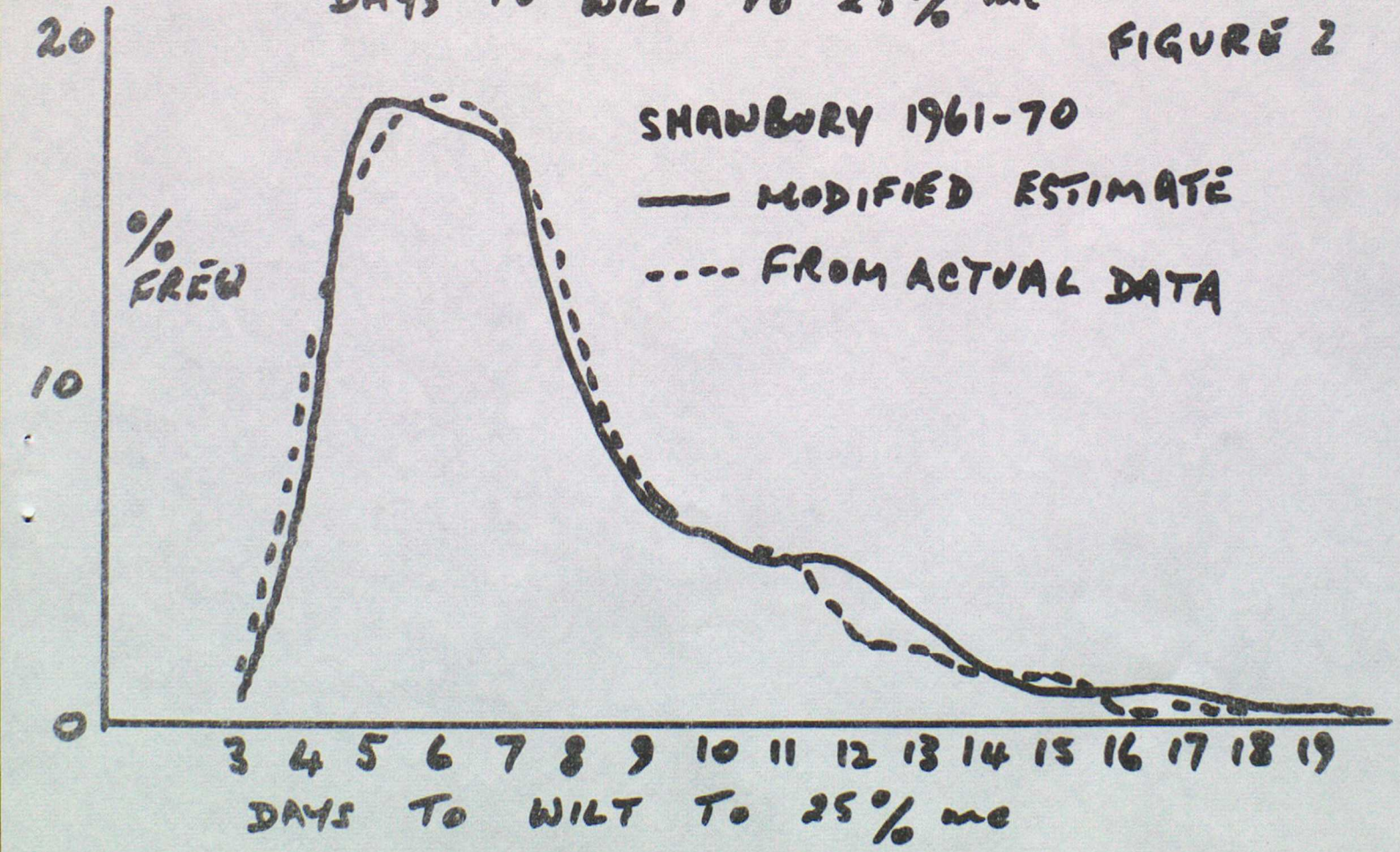


FIGURE 2



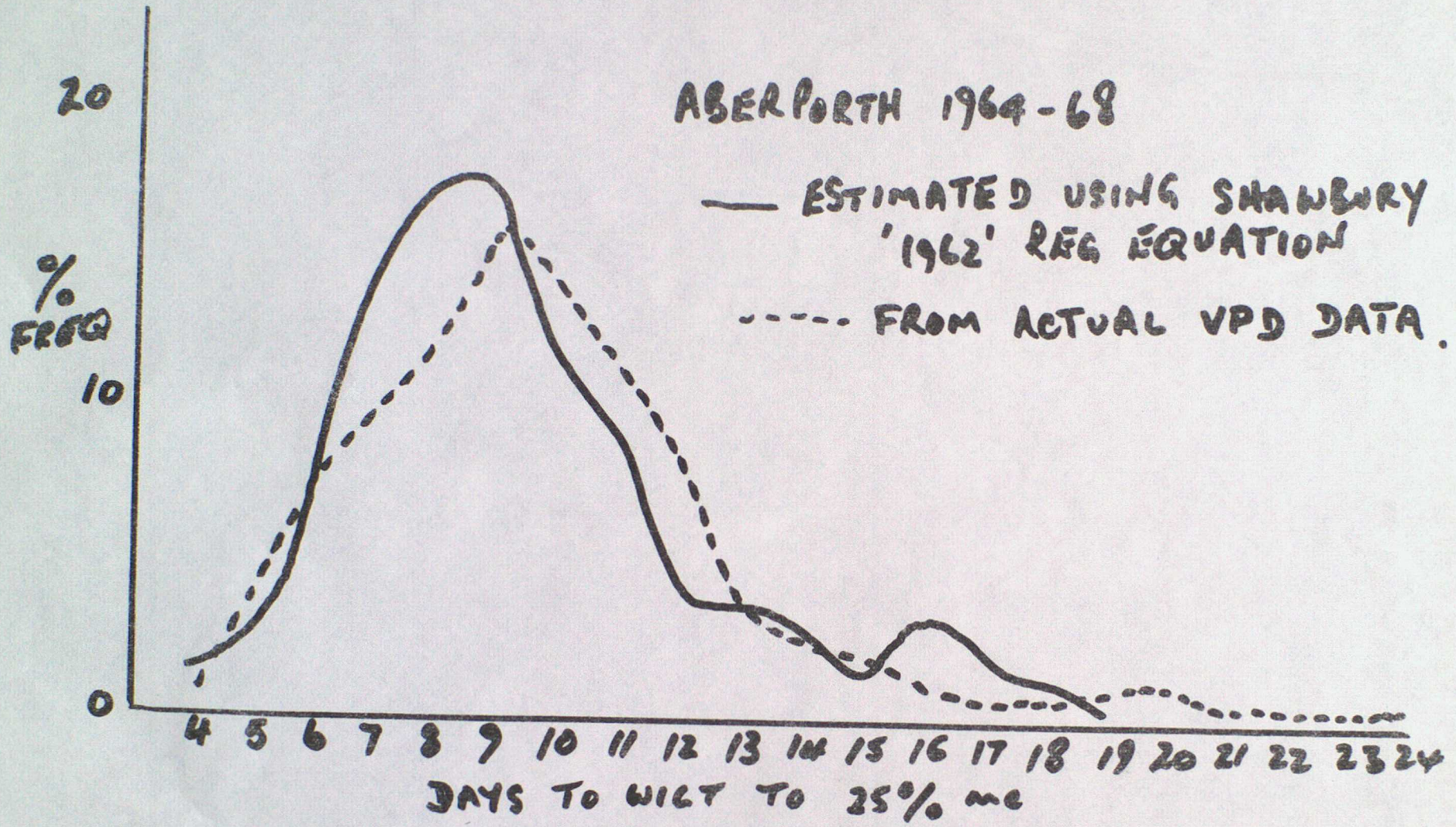

ABERPORTH 1964-68
— ESTIMATED USING SHAWBURY '1962' REG EQUATION
----- FROM ACTUAL VPD DATA.
20
%
FREQ
10
0
4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
DAYS TO WILT TO 25% mc

FIGURE 4

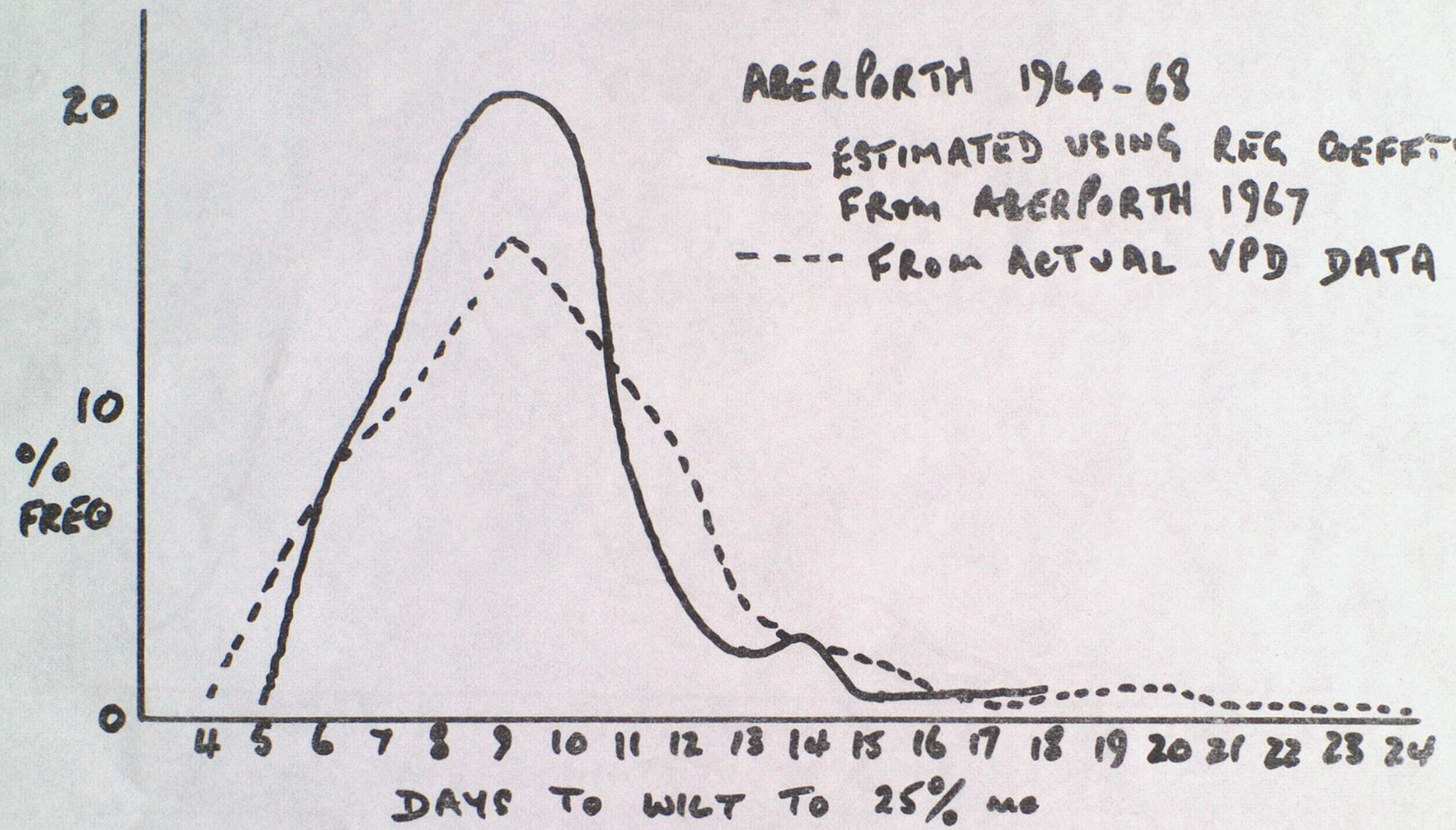

ABERPORTH 1964-68
ESTIMATED USING REG COEFFTS FROM ABERPORTH 1967
FROM ACTUAL VPD DATA
20
10
0
% FREQ
4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
DAYS TO WILT TO 25% mc

FIGURE 6

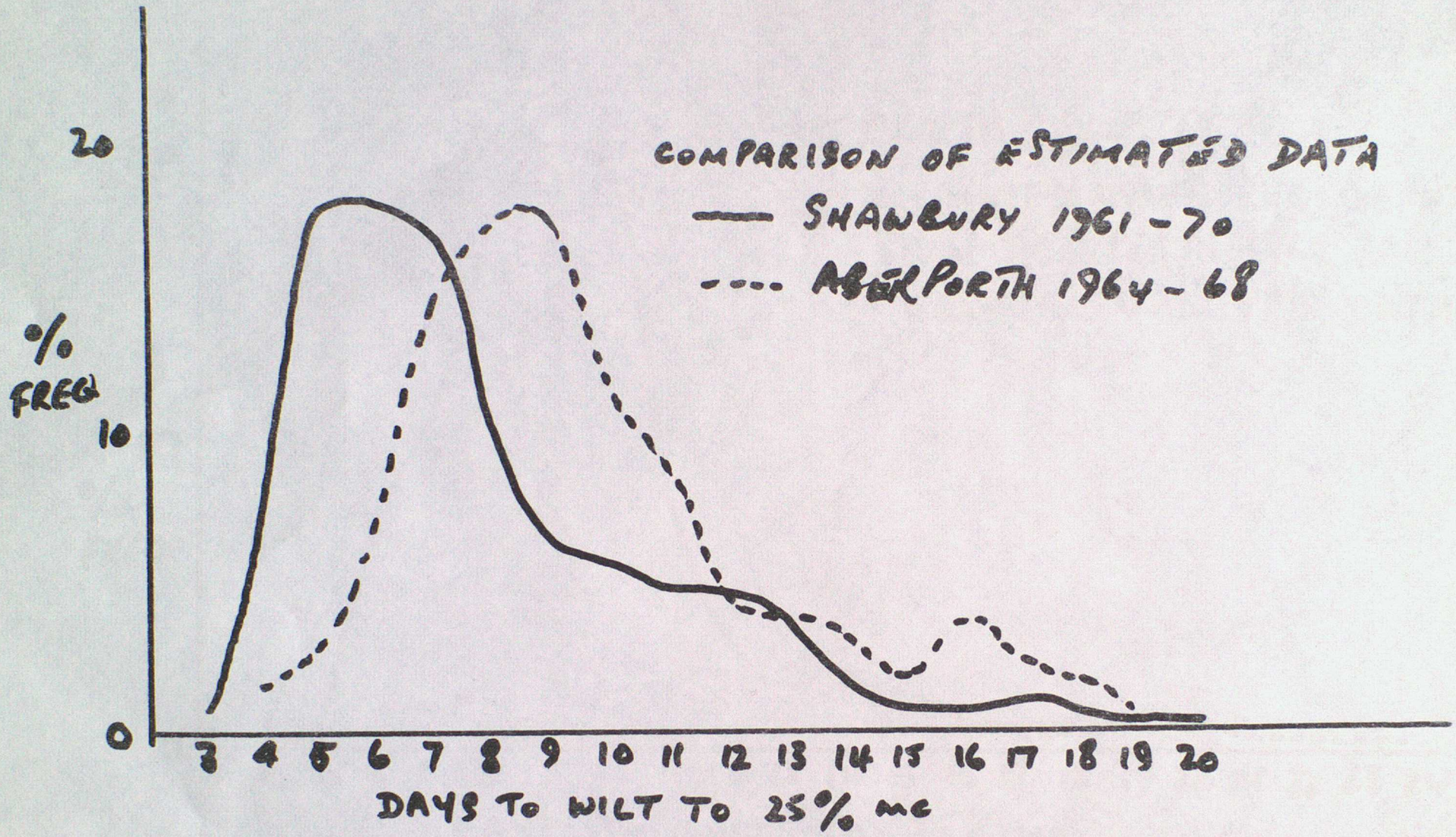

COMPARISON OF ESTIMATED DATA
SHANBURY 1961-70
ABERPORTH 1964-68
20
10
0
% FREQ
3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
DAYS TO WILT TO 25% mc

FIGURE 6

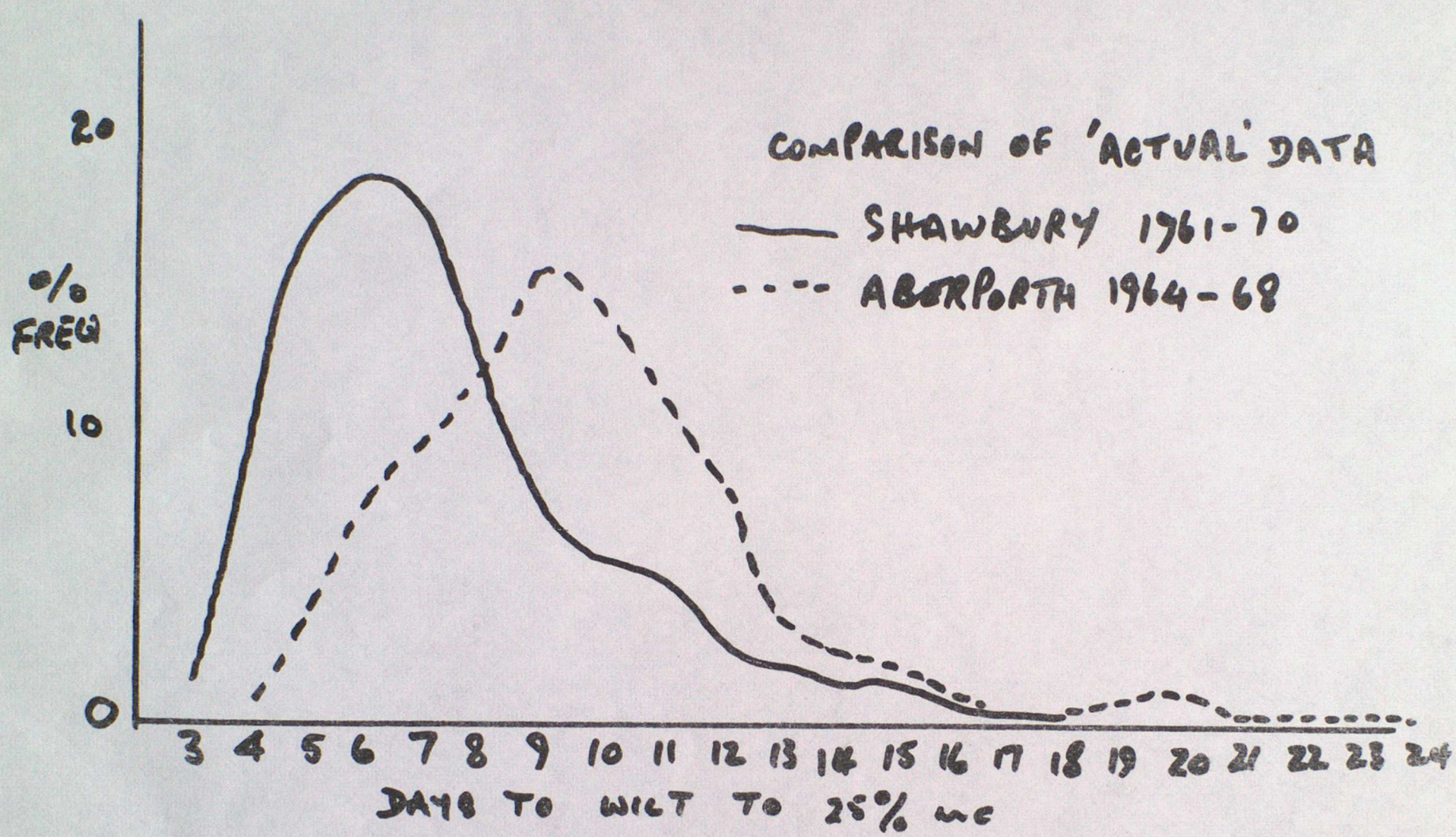

COMPARISON OF 'ACTUAL' DATA
SHAWBURY 1961-70
ABERPORTH 1964-68
20
10
0
% FREQ
3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
DAYS TO WILT TO 25% mc

FIGURE 7

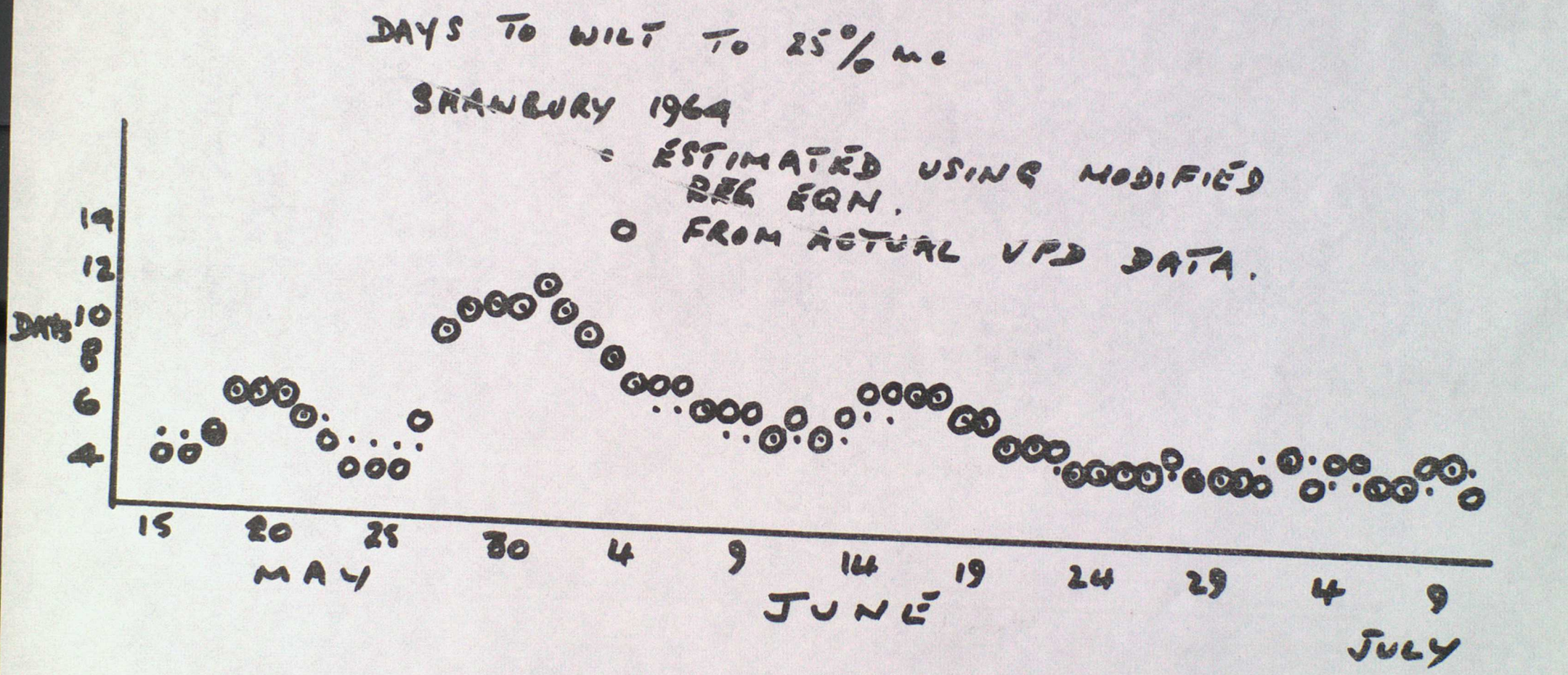

DAYS TO WILT TO 25% mc
SHANBURY 1964
= ESTIMATED USING MODIFIED PEN EQN.
o FROM ACTUAL VPD DATA.
DAYS
14
12
10
8
6
4
15
20
25
30
4
9
14
19
24
29
4
9
MAY
JUNE
JULY

FIGURE 8